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Ammonia efflux affects accuracy of CO_2 emission estimated by alkali-trap method

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Introduction

The alkali-trap method (absorption of CO_2 in NaOH solution and titration of the remaining NaOH with HCl) is frequently used to estimate soil CO_2 emissions (Carter and Gregorich, 2008). With alkaline soils, however, it might be possible to underestimate soil CO_2 emissions due to slight dissolution of ammonia into NaOH solution and production of extra OH^- ions. So the main goals of this study were:

- To investigate the dynamics of C and N emissions from soils under different land uses and climatic conditions with pH values from 7.5 to 8.
- To examine the effects of ammonia on the results of alkali-trap method.

Materials and Methods

Nine different long-term land uses (coniferous or deciduous trees, farmland and rangeland) in three different climatic regions (arid, semi-arid and humid) from Northern-Central Iran were selected. Top soil samples were incubated for 8 months at 25°C with and without maize litter addition. CO_2 emission rates were measured during 1, 3, 5, and 7 days after the beginning of the experiment and afterwards weekly by alkali-trap method. Measurement of carbon and nitrogen in the oven-dried aliquots of alkali solutions by an elemental analyzer (LECO TruSpec) after addition of 0.5 M $SrCl_2$ were performed for selected dates. Cumulative CO_2 effluxes obtained by titration were adjusted to the level of elemental analyzer results using linear regressions for both treatments.

Results and Discussion

The amount of carbon measured by titration was inversely related to the amount of nitrogen measured by elemental analyzer (see example in Fig. 1) which caused an underestimation of CO_2 emission (up to more than 40%) by the titration method. Due to the absorption of gaseous N species (probably NH_3), additional OH^- ions had build up in the NaOH solution and this biased the titration results.

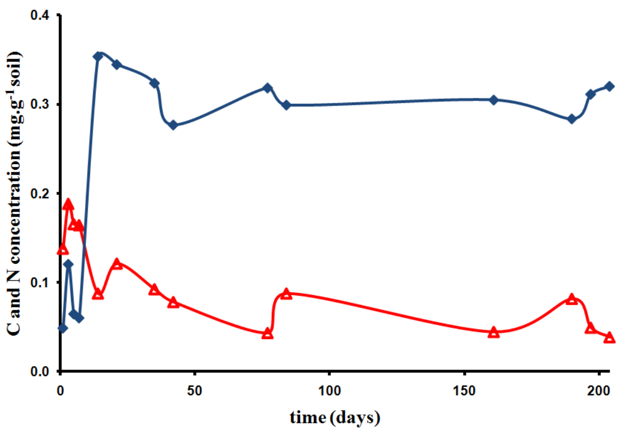

Fig. 1: Inverse relationship between CO_2-C and nitrogen measured by titration and elemental analyzer, respectively for arid range land in without maize treatment. (Δ) CO_2-C, (♦) NH_3-N.

The maximum CO_2 efflux occurred at the third day by the titration method which was

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higher in the maize treatment. But by carbon analyzer, another peak of high CO_2 emission also exists (only in the maize treatment) which occurred some days after the first (see example in Fig. 2). After the second peak there is no difference between the two treatments and the amounts of CO_2 emission are the same and at steady state which is completely different to the titration results with lots of irregularities in both treatments (data not shown). The first peak which is visible in both of our treatments can be related to the fast growing organisms (r strategists) (Fontaine et al., 2003). The second peak, however, may be formed by slowly growing organisms (K strategists) which normally use organic carbon formed by r strategists or their dead bodies.

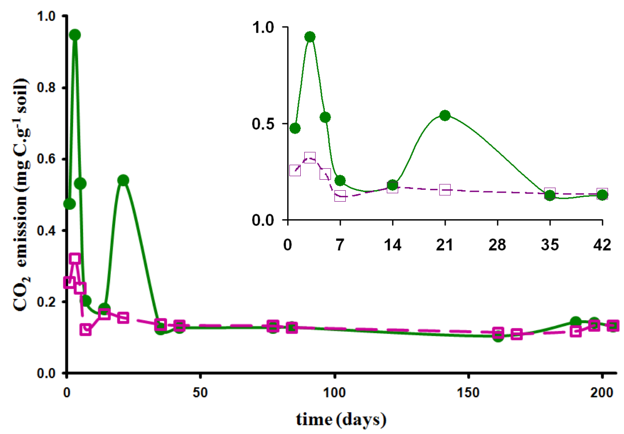

Fig. 2: Soil CO_2 emissions measured by elemental analyzer for Haloxylon aphyllum *in arid region. (●) maize treatment, (□) without maize treatment.*

According to the adjusted titration results (Fig. 3), CO_2 effluxes differed among land uses before and after addition of maize litter to the soil (Fig. 4). Deciduous species followed by arid range lands showed the lowest, *Pinus eldarica* and deforested land the intermediate, and farm land and *Picea abies*, the highest increase of CO_2 emissions in comparison to the treatment without litter addition. Coniferous species showed the highest absolute amount of cumulative CO_2-C in both treatments compared to the other land uses. The quantity and quality of soil organic matter may be responsible for such differences. Soils with higher soil organic carbon produce more CO_2 and vice versa (Accoe et al., 2003). Humic substances which are resistant to microbial degradation in one climatic condition may be less stable in the other temperature and moisture regimes and vice versa. Different soil properties, especially clay content, and also microbial composition and population among land uses can influence soil organic matter quality and decomposition processes.

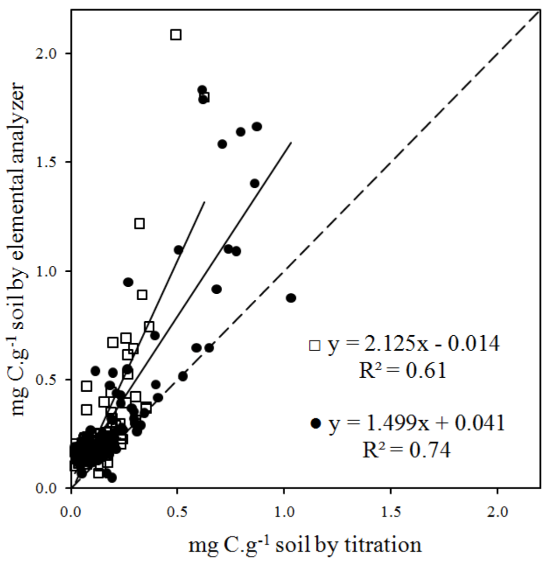

Fig. 3: The relationship between the amounts of CO_2-C measured by titration and carbon measured by elemental analyzer for without maize (□) and with maize treatment (●)

Conclusions

The accuracy of the alkali-trap method to measure soil CO_2 efflux was affected by emission of N-rich gases (probably NH_3) and their absorption in NaOH solution. For soils with pH > 7, the elemental analyzer method should be preferred towards titration. Calibration of titration results with a selection of elemental analyzer results could be a good alternative as shown for nine Iranian soils and land uses of different climatic regions.

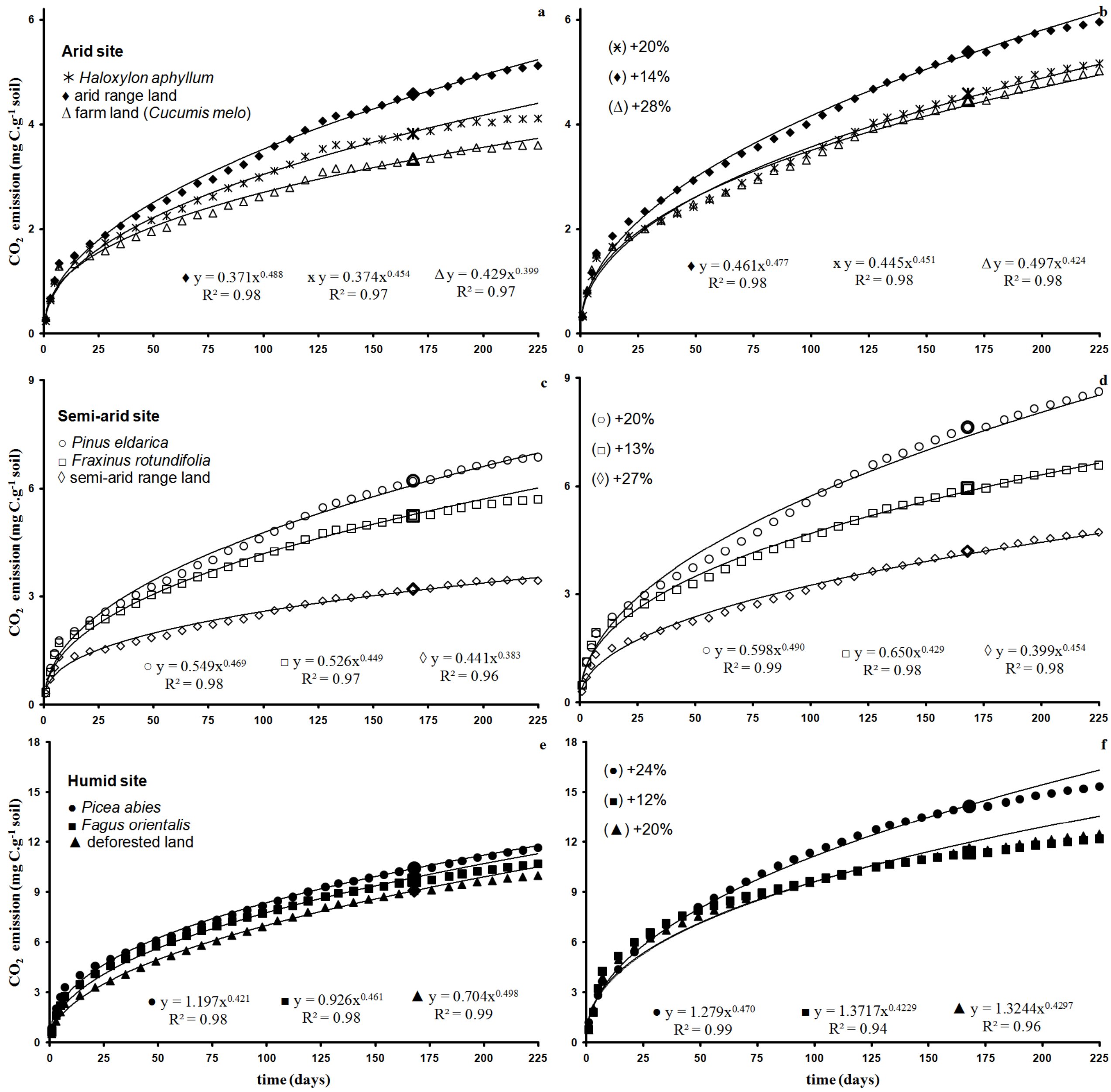

Fig. 4: Cumulatively emitted CO_2-C (n = 3) obtained by titration, but adjusted by elemental analyzer, in: (a) and (b), arid; (c) and (d), semi-arid; and (e) and (f), humid region (Bold symbols are estimated data for day 168 as mean of three dates before and after the mentioned time).

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